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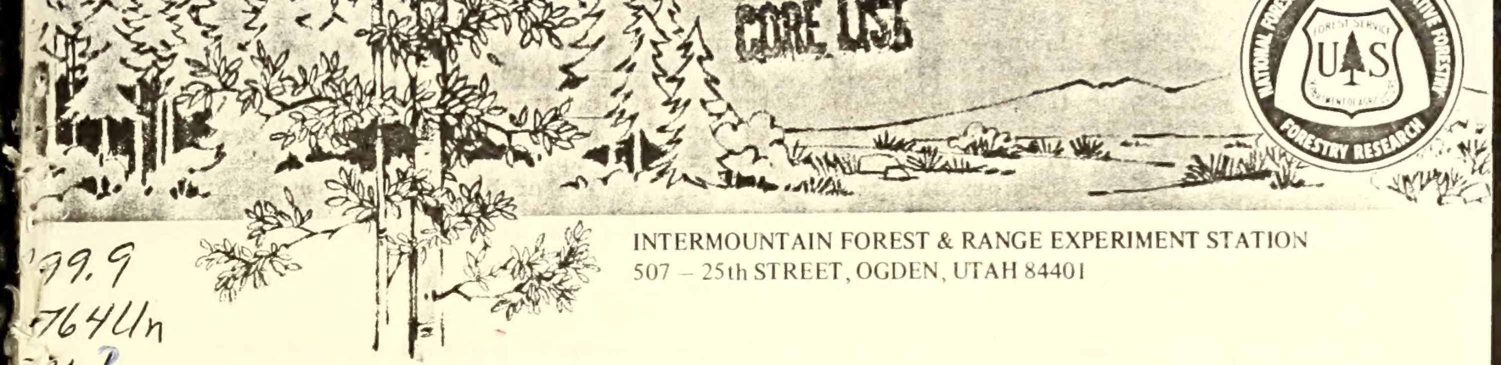

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GENETIC VARIATION IN A PROVENANCE TEST OF 16-YEAR-OLD PONDEROSA PINE

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ABSTRACT

Trees at age 16 representing 13 provenances of ponderosa pine were compared in tests at two planting sites. Provenances represented a small portion of the species range in northern Idaho. Genetic variation among provenances was apparent for tree height, diameter at the ground, and number of branches in the upper two whorls. Trees that suffered the most damage from snow at the most severe site represented provenances characterized by the greatest growth rate.

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Racial variation characterizes the genetic system of ponderosa pine (*Pinus ponderosa*). Tests of provenances representing much of the species range show regional variation for numerous traits (Steinhoff 1970; Wells 1964; Squillace and Silen 1962; Hanover 1963; Wright and others 1969). The genetic variation that differentiates provenances within regions (Wright and others 1969) may be related to altitude of the provenance (Callaham and Liddicoet 1961).

In northern Idaho, ponderosa pine forms climax forests near the prairie-forest transition; it is a major seral component of the Douglas-fir (*Pseudotsuga menziesii*) series of habitats and the *Abies grandis-Pachistima myrsinites* habitat type (Daubenmire and Daubenmire 1968). Provenance tests that involved a small portion of the species

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range in northern Idaho were initiated by Potlatch Corporation to locate suitable sources of seeds for reforestation.[2] Because of the blister rust epidemic affecting western white pine (*Pinus monticola*), alternative pine species were desirable for reforestation. The objective of the tests reported here was to determine the existence of provenances capable of producing seed for trees adapted to the western redcedar (*Thuja plicata*) and hemlock (*Tsuga heterophylla*) series of habitats for which ponderosa pine generally is not suited.

MATERIALS AND METHODS

Two-year-old seedlings representing 13 provenances were planted in 1961 on two sites (fig. 1). Trees from nine provenances were planted on the Washington Creek site. This site is a *Thuja plicata-Pachistima myrsinites* habitat type at 1,220-m elevation; for each provenance, 100 trees were planted at a spacing of 2 m^2 in each of two square plots located at random throughout the planting.

The Crane Creek planting is an *Abies grandis-Pachistima myrsinites* habitat type at 880-m elevation and contained seedlings representing 11 provenances. Here only one provenance was represented in two plots. However, for each provenance 125 to 3,000 trees were planted at a spacing of about 2 by 3 m for each provenance in long row plots that extended the length of the relatively uniform site.

Hence, the Washington Creek plantation contained two replicates. The Crane Creek Plantation was not replicated except for one provenance.

After the trees were 16 years old, the following data were obtained for trees undamaged by snow, porcupines, insects, and cattle: 16- and 11-year heights, diameter at the ground, and number of branches in the upper two whorls. At Crane Creek, a systematic sample of 67 to 75 trees for each provenance was taken so that observations were available from entire plots. Because of high mortality and snow damage at the Washington Creek site, only 12 to 73 trees were measured for each provenance. Percentages of mortality and trees damaged by snow were estimated for each plot at Washington Creek. Snow damage included major bends in the stem, grotesquely deformed stems and branches, and broken tops. There was virtually no snow damage at Crane Creek, and mortality was minimal.

Although the Crane Creek plantation was essentially unreplicated, data from this planting are amenable to statistical analyses. Data from the one provenance that was established in two plots could be tested for experimental errors; a large number of trees were planted for each provenance; plots were established in long rows that traversed much of the environmental heterogeneity of the site; and, corroborative data were available from the Washington Creek planting.

Statistical analyses included an analysis of covariance of 16-year height on 11-year height and analyses of variance for all variables. Analyses were made to estimate effects of: (1) provenances at each site, (2) plots for the Brown's Creek provenance at the Crane Creek site, and (3) provenances, sites, and their interaction for the seven provenances common to both planting sites. Planting sites were considered fixed variates, and plots and provenances were random variates. Analyses of weighted means for unequal subclass numbers were made on the original data.

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[2] Use of trade or firm names is for reader information only, and does not constitute endorsement by the U. S. Department of Agriculture of any commercial product or service.

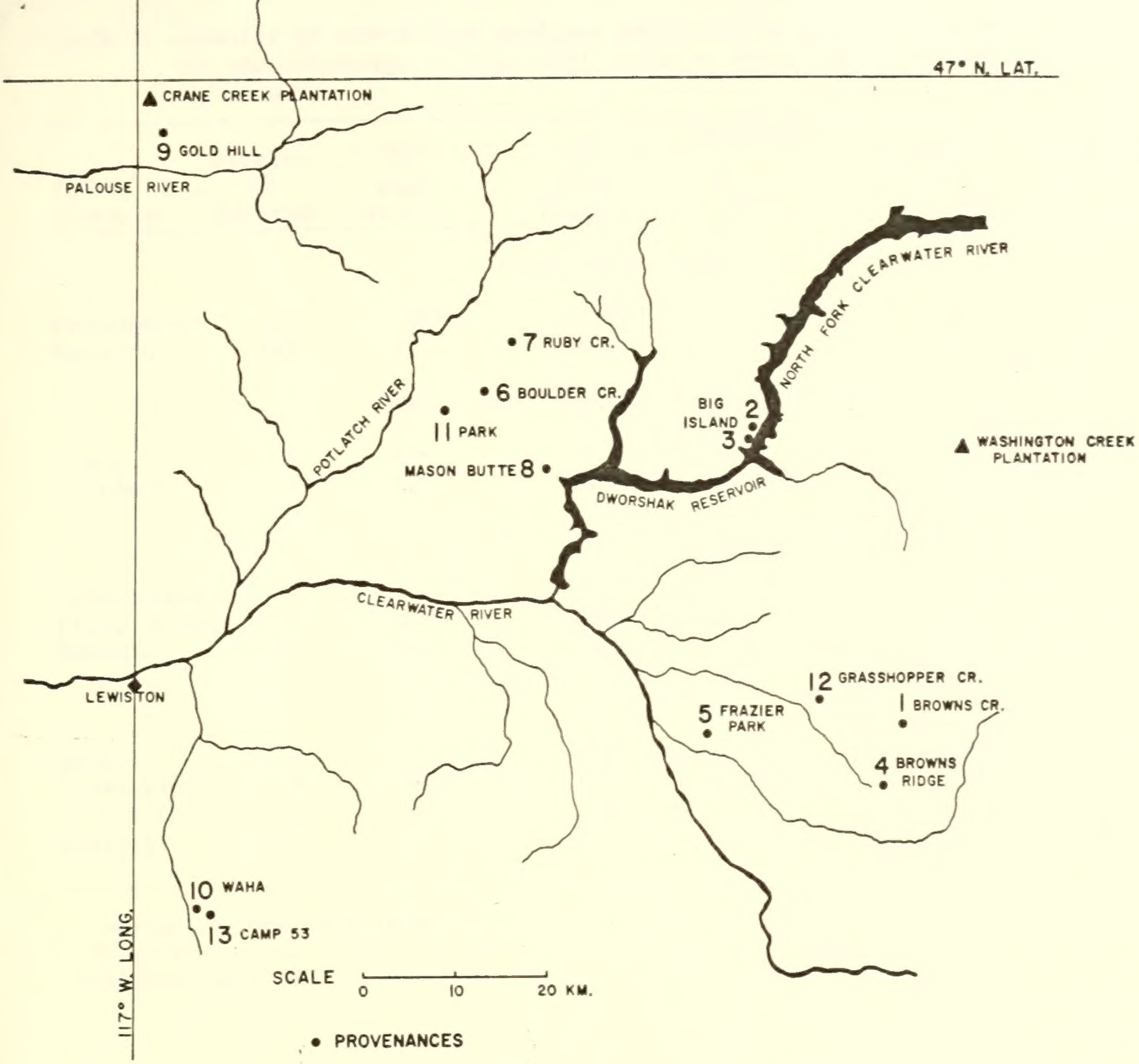

Figure 1.--Drainage map of a portion of northern Idaho showing location of provenances and plantations.

RESULTS AND DISCUSSION

Results of statistical analyses for the Crane Creek plantation (table 1) suggest genetic differences among provenances for all variables. However, the validity of these results is questionable. Effects of plots within provenances for data from Washington Creek were so large that it was impossible to detect significant effects of provenances. Effects of plots for the Brown's Creek provenance, the only replicated provenance at the Crane Creek site, were significant for three analyses. Mean differences associated with provenances at the Washington Creek site were of a magnitude similar to those at Crane Creek.

Table 1.--*Results of statistical analyses presented as intraclass correlations or the percentage of the total variance associated with each source of variance*

Source of variance	Degrees of freedom	Variables				
		16-year height	11-year height	$d_{y.x}$[1]	Diameter at ground	Branches in upper two whorls
		CRANE CREEK PLANTATION				
Provenances	10	9**	10**	7**	8**	17**
Residual	794	91	90	93	92	83
		BROWN'S CREEK PROVENANCE AT CRANE CREEK				
Plots	1	12*	5	4	10*	15**
Residual	73	88	95	96	90	85
		WASHINGTON CREEK PLANTATION				
Provenances	8	0	6	13	0	0
Plots in Prov.	9	36**	31**	7*	32**	18**
Residual	347	64	63	80	68	82
		SITES COMBINED				
Sites	1	0	0	0	28**	0
Provenances	6	16**	17**	8**	5**	17**
Site × Prov.	6	6**	4**	1	4**	8**
Residual	784	78	79	91	63	75

[1] Deviation from regression of 16-year height on 11-year height.
*Significance of F value at the 95 percent level of probability.
**Significance of F value at the 99 percent level of probability.

Therefore, significant effects of provenances for the Crane Creek site seem inconsistent. However, consistent mean values for provenances at both sites (table 2) substantiate significant effects for provenances. Trees from the Big Island provenances were among the tallest at both plantings; those from Boulder and Ruby Creeks were the shortest. Diameters of trees from Brown's Ridge were among the largest at both plantings. Trees from Ruby Creek and Brown's Ridge produced the most branches; those from Frazier Park produced the fewest; and during the last 5 years, growth rates of trees from Frazier Park were far below the average at both sites.

Although diameters of trees growing at Washington Creek averaged 2 cm larger than those at the Crane Creek site, effects of planting sites were negligible for other variables (table 1). Most of the effects of planting sites were expressed by mortality and snow damage. Virtually no mortality nor snow damage occurred at the Crane Creek plantation. At Washington Creek, mortality averaged 53 percent, and 42 percent of the living trees were damaged by snow. Nevertheless, undamaged trees grew similarly on both sites. Except for snow damage, effects of interaction between provenances and sites are negligible. Effects were statistically significant, but intraclass correlations were low and were probably related to large inequalities in subclass numbers.

Table 2.--*Mean values representing each provenance at each planting site*

Provenance	Elevation	Trees in cone collection	Plantation											
			Crane Creek					Washington Creek						
			16-year height	11-year height	$d_{y.x}$[1]	Diameter	Branches	16-year height	11-year height	$d_{y.x}$[1]	Diameter	Branches	Mortality	Snow damage
	M	*Number*	*M*	*M*	*M*	*Cm*	*Number*	*M*	*M*	*M*	*Cm*	*Number*	*Percent*	*Percent*
1 Brown's Creek	1040	[2]--	5.0	2.4	0	12.4	9.3	5.4	2.6	0.18	15.5	9.3	50	47
2 Big Island-1	1060	[2]--	5.5	2.8	.10	13.2	9.8	5.5	2.9	-.02	15.5	8.8	45	67
3 Big Island-2	670	[2]--	5.1	2.6	.06	12.9	9.4	5.9	3.1	.09	16.0	8.7	62	92
4 Brown's Ridge	1220	12	5.5	2.7	.16	13.9	10.4	5.1	2.5	.04	15.5	9.3	45	30
5 Frazier Park	980	1	4.8	2.5	-.26	11.6	7.6	5.1	2.7	-.20	15.7	7.9	57	67
6 Boulder Creek	1070	12	4.7	2.3	0	12.9	10.1	4.5	2.1	.04	13.9	9.4	70	5
7 Ruby Creek	880	12	4.7	2.2	0	11.4	8.4	4.8	2.2	.14	14.2	9.4	45	7
8 Mason Butte	980	12	4.7	2.2	.15	11.9	9.2	--	--	--	--	--	--	--
9 Gold Hill	1160	5	5.0	2.6	-.10	12.4	9.2	--	--	--	--	--	--	--
10 Waha	1280	4	5.1	2.7	-.16	12.4	9.0	--	--	--	--	--	--	--
11 Park Community	920	[2]--	5.1	2.5	0	12.4	8.6	--	--	--	--	--	--	--
12 Grasshopper Creek	1040	[2]--	--	--	--	--	--	5.1	2.8	-.12	13.5	8.2	57	52
13 Camp 53	1280	3	--	--	--	--	--	4.9	2.5	-.22	13.7	8.6	50	9

[1] Mean deviation from regression of 16-year height on 11-year height.

[2] Cones were collected from an unknown number of trees.

The percentage of trees damaged by snow varied among provenances (table 2), and the amount of damage was related to mean height of undamaged trees. The provenance characterized by the tallest trees also had the largest percentage of trees damaged by snow. Conversely, the three provenances that had the lowest percentage of trees damaged by snow also had the smallest trees. This suggests that genetic variation among provenances in growth potential is inversely correlated with variation for strength to withstand large accumulations of snow. However, it is also possible that observed differences in snow damage actually reflect variation in growth rate and are confounded by differential mortality associated with provenances.

Snow damage in pole-sized ponderosa pine plantations often injures the tallest trees and is directly related to stand density (Powers and Oliver 1970). Yet damage from snow has been observed in ponderosa pines as small as 2 m (Oliver 1970); and little relationship between the percentage of trees damaged and mortality, a measure of stand density, was apparent (table 2). Therefore, growth rate and strength to withstand large accumulations of snow seem to represent different but correlated traits that genetically differentiate provenances. Similar results were obtained from 20-year-old provenance trials of ponderosa pine in California (Callaham and Liddicoet 1961).

Data from the Washington Creek plantation suggest that provenances of ponderosa pine are sufficiently heterogeneous to produce progenies preadapted to environments infrequently encountered by the species. Trees from each provenance produced offspring capable of withstanding the severe environment at Washington Creek; growth rates of preadapted trees were similar to those of trees growing at the Crane Creek site, which represents a common ponderosa pine habitat. That different percentages of preadapted trees characterized provenances attests to genetic variability.

Several tentative conclusions can be made from these results. Due to the superior growth rate but susceptibility to snow damage, seeds from the Big Island provenances are recommended for reforestation in areas where snow accumulations are light. Alternative sources of seed are available for areas in which heavy snow accumulations are expected. High growth rates accompanied by moderate amounts of snow damage can be expected from trees derived from Brown's Creek and Brown's Ridge. Maximum resistance to snow damage, but slow growth, can be expected from trees representative of Boulder and Ruby Creeks. Undamaged trees growing at the Washington Creek site represent materials suitable for development of races of ponderosa pine that are adapted to the western redcedar *(Thuja plicata)* series of habitat types.

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